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NACA

RESEARCH MEMORANDUM

A WIND-TUNNEL INVESTIGATION OF THE USE OF SPOILERS FOR OBTAINING STATIC LONGITUDINAL STABILITY OF A CANARD-MISSILE MODEL IN REVERSE FLIGHT

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SUMMARY

An investigation has been conducted in the Langley stability tunnel of the use of spoilers for obtaining static longitudinal stability of a model of a canard missile in reverse flight such as that occurring when the missile is launched rearward from an airplane. The low-speed static longitudinal stability characteristics were determined for forward flight of the missile without spoilers and for reverse flight of the missile with spoilers attached normal to the main supporting surface. The spoilers were 10, 20, 30, 40, and 50 percent of the wing chord in total height and protruded equal distances beyond the upper and lower surfaces of the wing along the entire span of the trailing edge of the wing.

At angles of attack up to 6°, 8°, and 11° and for the low speed range of these tests, stable pitching-moment slopes were obtained for reverse flight of the canard-type missile having rectangular surfaces by the use of spoilers having total heights of 30, 40, or 50 percent of the wing chord, respectively; however, reverse-flight stability was not obtained by the use of spoilers having total heights of 10 or 20 percent of the wing chord for any portion of the angle-of-attack range investigated. The increase in drag that attended the increases in spoiler height was about proportional to the exposed height of the spoiler.

INTRODUCTION

Attacks of one airplane on another are frequently delivered from the rear in order to avoid firing deflection shots that are less accurate than shots fired from a rearward approach. This fact and the recent interest in the use of air-to-air guided missiles for the defense of aircraft (refs. 1 and 2) make the launching of missiles in this direction from defending aircraft of considerable importance. One means of launching

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missiles involves dropping properly fused missiles from the airplane as required. In this application the missile would be pointed to the rear and hence flying in the reverse direction when first dropped and in the normal direction when self-propelled.

The basic requirement for statically longitudinally stable canard missile is that the restoring moment caused by the rearward lifting surfaces be larger than the destabilizing moment caused by the forward lifting surfaces and the body. This requirement is usually met for normal flight by proper proportioning of the lifting surfaces and associated moment arms. One means of obtaining static stability for the canard missile in reverse flight is to eliminate the lift acting on the forward lifting surfaces. This objective might be accomplished by the use of spoilers which would be designed to fall away when the flight direction becomes normal.

The purpose of this investigation, then, was to determine by wind-tunnel tests the feasibility of obtaining static stability in reverse flight by the use of spoilers for a missile that is stable without spoilers in normal flight. A model of a canard missile having rectangular lifting surfaces of aspect ratio 2 was chosen as a suitable configuration for this work. Tests were made to determine the static stability of this model in normal flight without spoilers and in reverse flight with flat-plate spoilers of five different heights. These spoilers had total heights, measured from below to above the wing, that varied from 10 to 50 percent of the chord of the wing. The spoilers were attached perpendicular to the trailing edge of the wing in normal flight along the entire span. In order to determine the influence of the spoilers on the aerodynamic characteristics of the wing alone, tests were also made on a proportionally larger wing.

SYMBOLS

All forces and moments are given with respect to a system of wind axes (fig. 1) which has its origin at the center of gravity of the model. The coefficients for the isolated wing were based on an equivalent body proportionately larger than that of the complete missile model. The coefficients and symbols used herein are defined as follows:

C_L	lift coefficient, L/qS_F
C_D	drag coefficient, D/qS_F
C_m	pitching-moment coefficient, M/qS_Fd
L	lift, lb

D	drag, lb
M	pitching moment, ft-lb
S_F	frontal area of body of model (0.0873 sq ft for complete missile data, 0.502 sq ft for isolated wing data)
d	maximum diameter of body of model (0.33 ft for complete missile data, 0.799 ft for isolated wing data)
q	dynamic pressure, $\frac{1}{2}\rho V^2$, lb/sq ft
ρ	mass density, slugs/cu ft
V	free-stream velocity, ft/sec
α	angle of attack of wing, deg
c	wing chord, ft
t/c	thickness of wing in percent of wing chord
h/c	total height of missile spoiler in percent of wing chord
W	isolated wing
S	spoiler

Subscripts:

10, 20, 30, 40, 50	indicates total spoiler height, $\frac{h}{c}$

MODEL AND APPARATUS

A canard-missile model consisting of a body, a wing, and a canard surface was employed for these tests. Details of this model are given in figure 2 and table I. The body of the model was made of mahogany to the dimensions given in figure 3 and the lifting surfaces, which had an aspect ratio of 2, were flat plates made of plywood. The canard surface had beveled leading and trailing edges, whereas only the leading edge of the wing was beveled. The trailing edge of the wing was not beveled in order to provide a sufficiently thick and flat surface to which the spoilers could be easily attached. The spoilers were made from $\frac{1}{16}$-inch Duralumin sheet and were bolted to the wing so that they protruded equal

distances above and below the wing-chord plane. These rectangular-shaped spoilers were similar to the spoilers shown in figure 4, extended along the entire span, and had total heights varying from 10 to 50 percent of the wing chord.

The isolated wing used in this investigation was also a rectangular flat plate of aspect ratio 2 made from $\frac{3}{4}$-inch plywood. The spoilers used on the wing were rectangular flat plates made from $\frac{1}{16}$-inch Duralumin sheet. Dimensions are given in figure 4.

The missile-model tests were conducted in the 6- by 6-foot test section of the Langley stability tunnel and the isolated-wing tests were conducted in the 6-foot-diameter rolling-flow test section. The models were attached to a single-strut support system which was fastened to a six-component balance system that measured the forces and moments acting on the models. The missile model was attached to the support strut at the same mounting point (an assumed center of gravity which was 28.61 inches from the nose) for normal and reverse flight. The isolated wing was mounted at the wing quarter chord.

TESTS

Tests were made at a dynamic pressure of 40 lb/sq ft to determine the static longitudinal stability of the missile model in normal and reverse flight without spoilers and in reverse flight with spoilers of various heights for an angle-of-attack range from -4° to about 32°. Tests were also made to determine the aerodynamic characteristics of the isolated wing without spoilers and with spoilers of various heights for an angle-of-attack range from -2° to about 30°. Tests with the 30, 40, and 50 percent wing-chord spoilers on the isolated wing were made at a dynamic pressure of 25 lb/sq ft because of the excessive buffeting which occurred with the larger spoilers at a dynamic pressure of 40 lb/sq ft.

The test conditions for the various configurations are given in the following table:

Configuration	Dynamic pressure, lb/sq ft	Reynolds number, based on wing chord
Missile	40	7.31×10^5
W	40	1.75×10^6
$W + S_{10}$	40	1.75×10^6
$W + S_{20}$	40	1.75×10^6
$W + S_{30}$	25	1.38×10^6
$W + S_{40}$	25	1.38×10^6
$W + S_{50}$	25	1.38×10^6

CORRECTIONS

No jet-boundary or blockage corrections were applied to the missile-model data. It was determined that these corrections were negligible because of the small volumes and areas of the body and lifting surfaces of the model as compared with the area of the tunnel cross section. No tare corrections were applied to the model C_L and C_m data because previous tests of a similar but larger model had shown the tares to be too small and erratic for application to the data. However, a tare correction of 0.382 was subtracted from the C_D data to correct for the drag of the exposed portion of the support strut.

The following jet-boundary corrections, determined from reference 3, were added to the data for the isolated wing and the isolated wing with spoilers of various sizes:

$$\Delta\alpha = 1.057C_L$$

$$\Delta C_D = 0.01844{C_L}^2$$

No blockage or tare corrections were applied to the isolated-wing or wing-spoiler data.

RESULTS AND DISCUSSION

The static longitudinal stability data of the missile model in reverse flight with and without spoilers and in normal flight without spoilers are presented in figure 5. The results show that the spoilers with heights greater than 20 percent of the wing chord produced large favorable changes in the pitching-moment characteristics of the model in reverse flight. The spoilers having total heights of 30, 40, and 50 percent of the wing chord produced stable pitching-moment slopes up to angles of attack of only 6°, 8°, and 11°, respectively; however, it should be noted that restoring moments were present up to 13°, 18°, and 22°, respectively. The model without spoilers and with the 10- and 20-percent wing-chord spoilers had unstable pitching-moment slopes throughout the angle-of-attack range. The model in normal flight without spoilers had a stable pitching-moment slope that extended to 20° and restoring moments were present for the entire angle-of-attack range.

The isolated-wing data of figure 6 are presented to aid in understanding the nature of the model pitching-moment results. The reverse-flight pitching-moment data of figure 5 show a marked similarity in shape of the curves to the wing-spoiler lift data of figure 6. It appears from this fact that the loss in lift caused by the spoilers was the predominant factor in producing the restoring moments that increased the reverse-flight stability.

Figure 7 presents the variation of C_D with exposed height of the spoiler. These data show that ΔC_D is proportional to the exposed height of the spoiler at 0° angle of attack and that the increase in drag caused by the increase in spoiler size was greatest at low angles of attack. The drag of the larger spoilers should be beneficial in decelerating the missile and thus in aiding in the reversal of flight.

It was observed in the static-stability tests of the isolated wing that the larger spoilers created a condition of violent buffeting at a dynamic pressure of 40 lb/sq ft which could be eliminated by reducing the dynamic pressure to 25 lb/sq ft. Although the missile-spoiler configuration tested at 40 lb/sq ft was free from any buffeting caused by the larger chord spoilers, it is thought likely that the larger chord spoilers would cause the buffeting condition to appear at the high dynamic pressures encountered in actual launchings.

CONCLUDING REMARKS

From the results of this investigation, it can be seen that obtaining stable pitching-moment slopes of a canard missile in reverse flight by the

use of spoilers is feasible at angles of attack up to 11° in the low speed range of these tests. However, tests at high subsonic speeds for providing information relative to buffeting and dynamic stability calculations and experimental studies involving aerodynamic disturbances, such as those occurring when a missile is launched rearward from an airplane, are necessary before the practicality of these spoilers for use in obtaining stability in reverse flight can be definitely established.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., April 27, 1954.

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TABLE I

GEOMETRIC CHARACTERISTICS OF CANARD-MISSILE MODEL

Body:	
Length, in.	48.0
Diameter, in.	4.0
Fineness ratio	12
Wing:	
Aspect ratio	2.0
Taper ratio	1.0
Sweep of quarter-chord line, deg	0
Airfoil section	Flat plate
Thickness ratio, t/c	0.05
Total area, sq in.	112.5
Span, in.	15.0
Chord, in.	7.5
Canard surface:	
Aspect ratio	2.0
Taper ratio	1.0
Sweep of quarter-chord line, deg	0
Thickness ratio, t/c	0.0525
Total area, sq in.	45.125
Span, in.	9.5
Chord, in.	4.75

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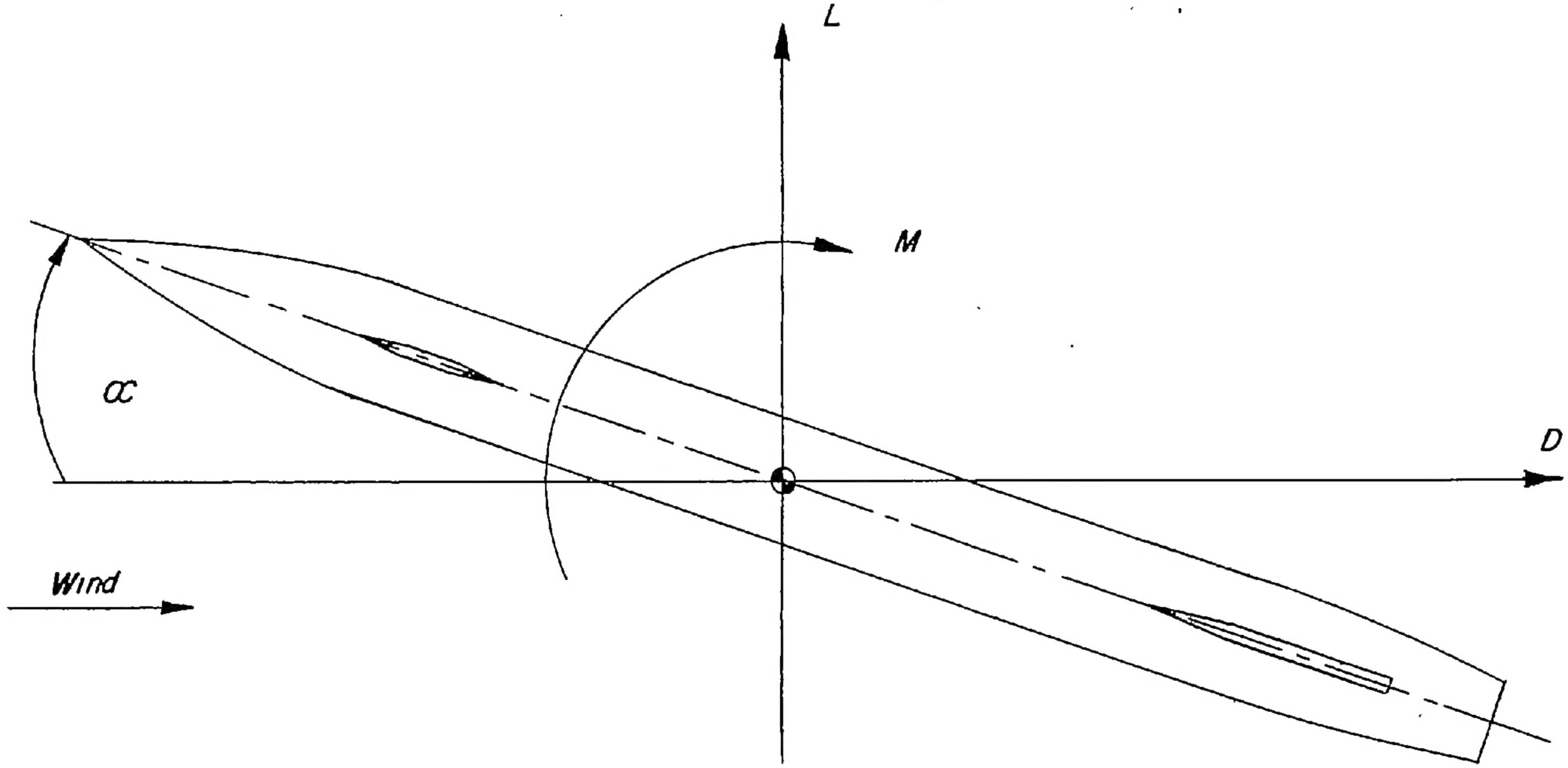

Figure 1.- System of wind axes. Arrows indicate positive direction of forces, moments, and angles.

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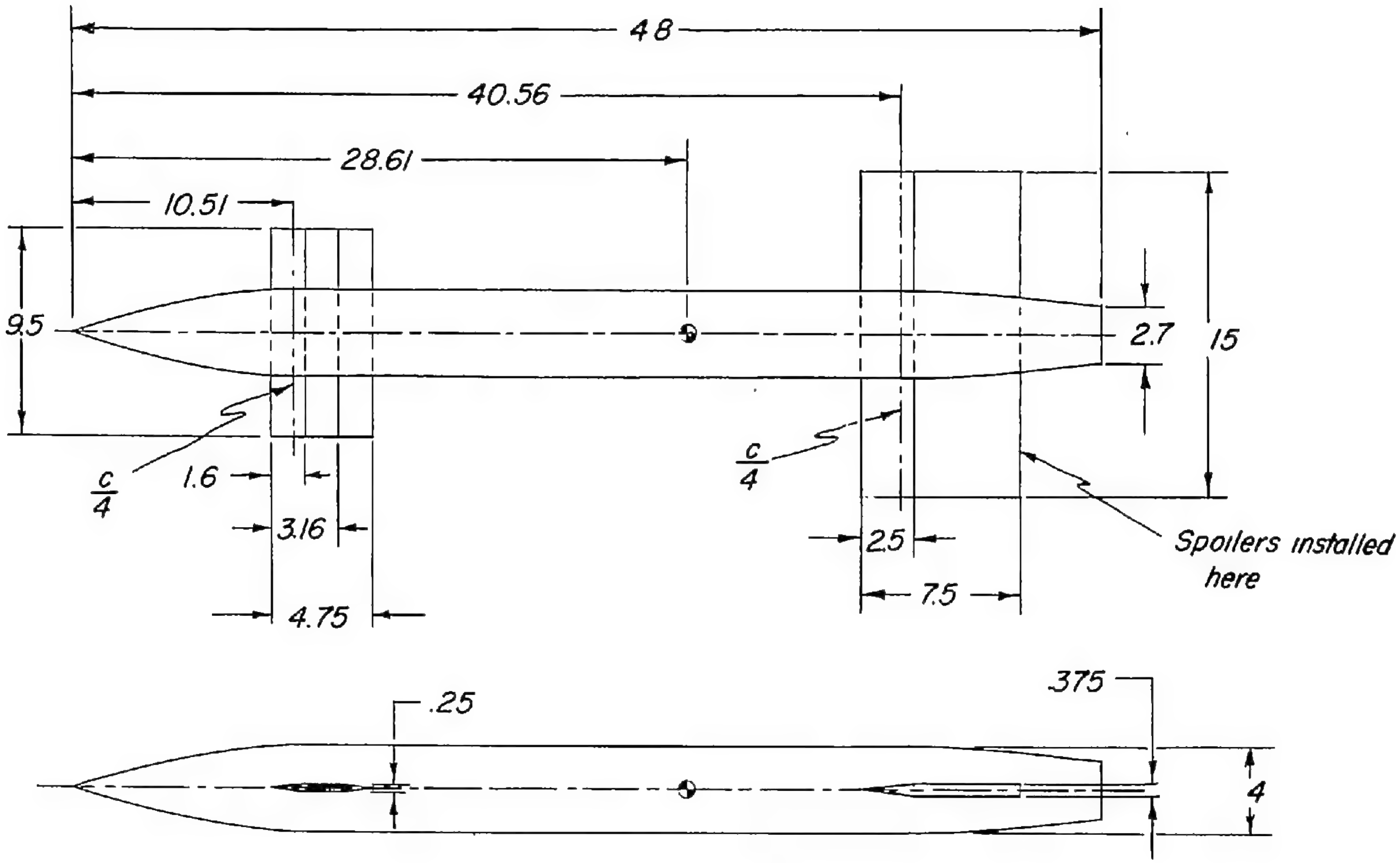
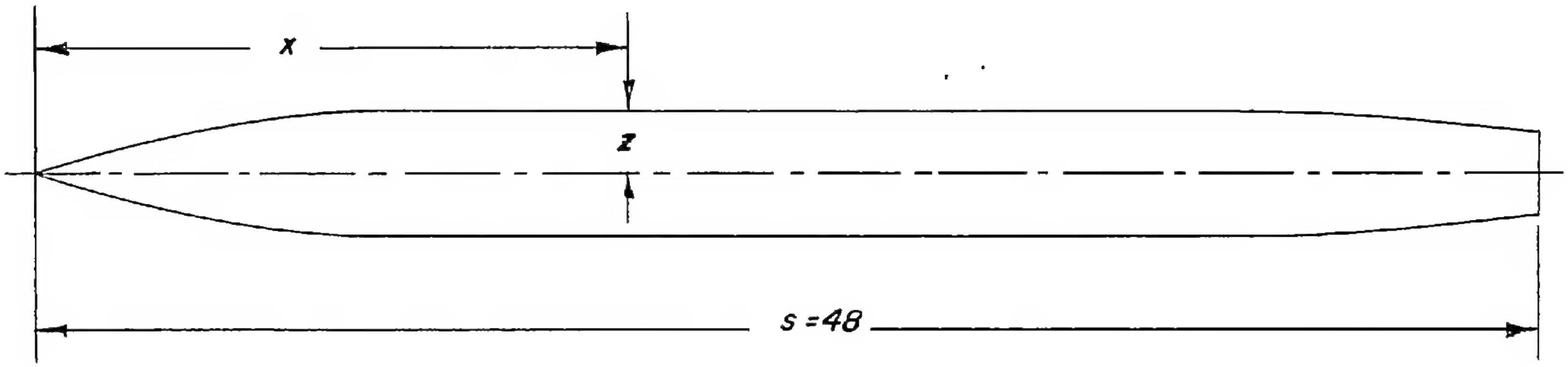


Figure 2.- General arrangement of canard-missile model. (All dimensions are in inches.)



x/s	z/s
0	0
.006	.0017
.009	.0024
.015	.0041
.030	.0080
.060	.0154
.090	.0222
.120	.0284
.180	.0387
.208	.0417

x/s	z/s
.208	.0417
.250	
.500	
.750	
.812	.0417
.833	.0410
.874	.0385
.916	.0354
.958	.0317
1.000	.0281

Figure 3.- Body ordinates.

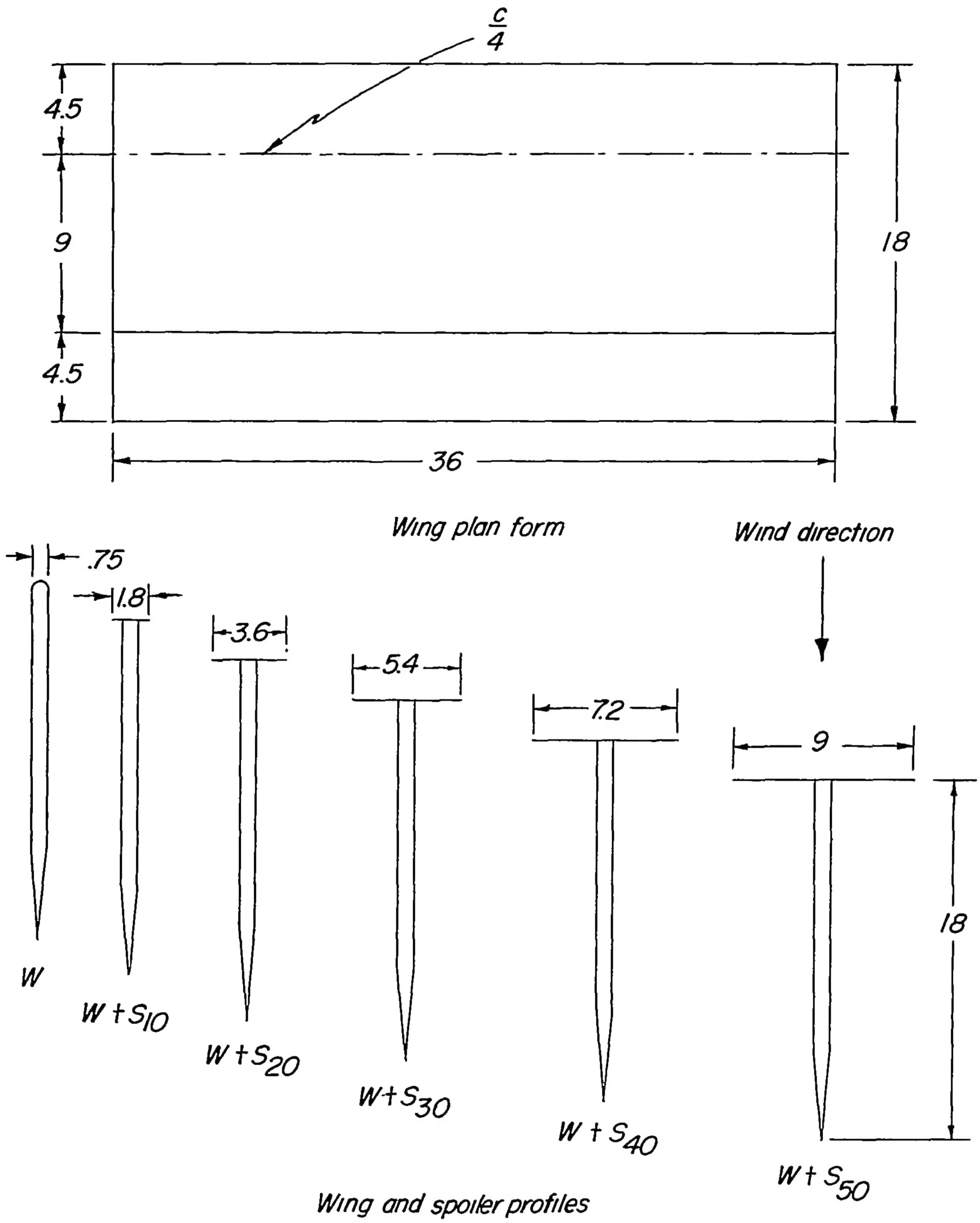


Figure 4.- Plan form and profiles of isolated wing with spoilers. (All dimensions are in inches.)

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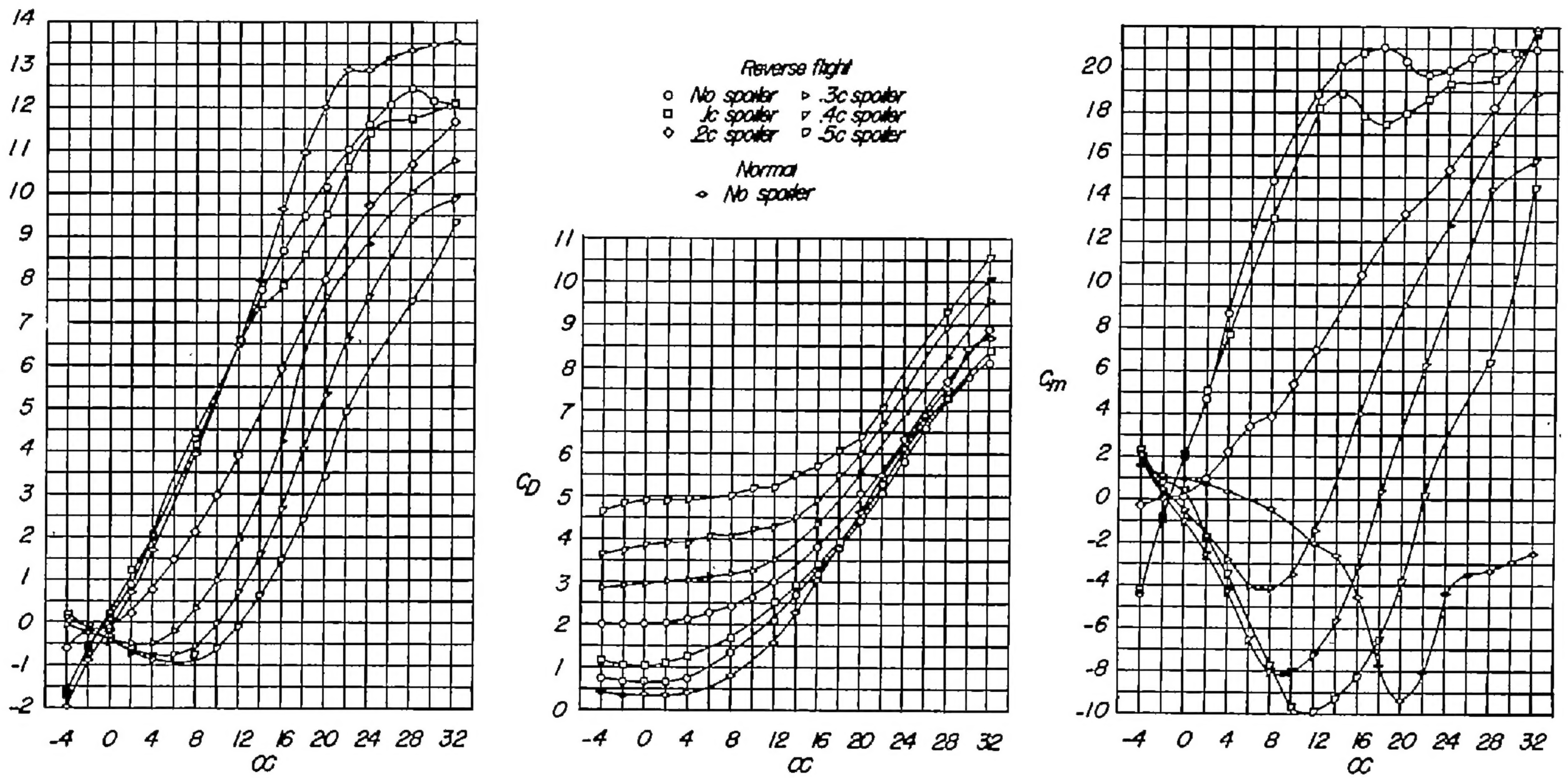

Figure 5.- Effect of spoiler height on the variation of C_L, C_D, and C_m with α for missile model.

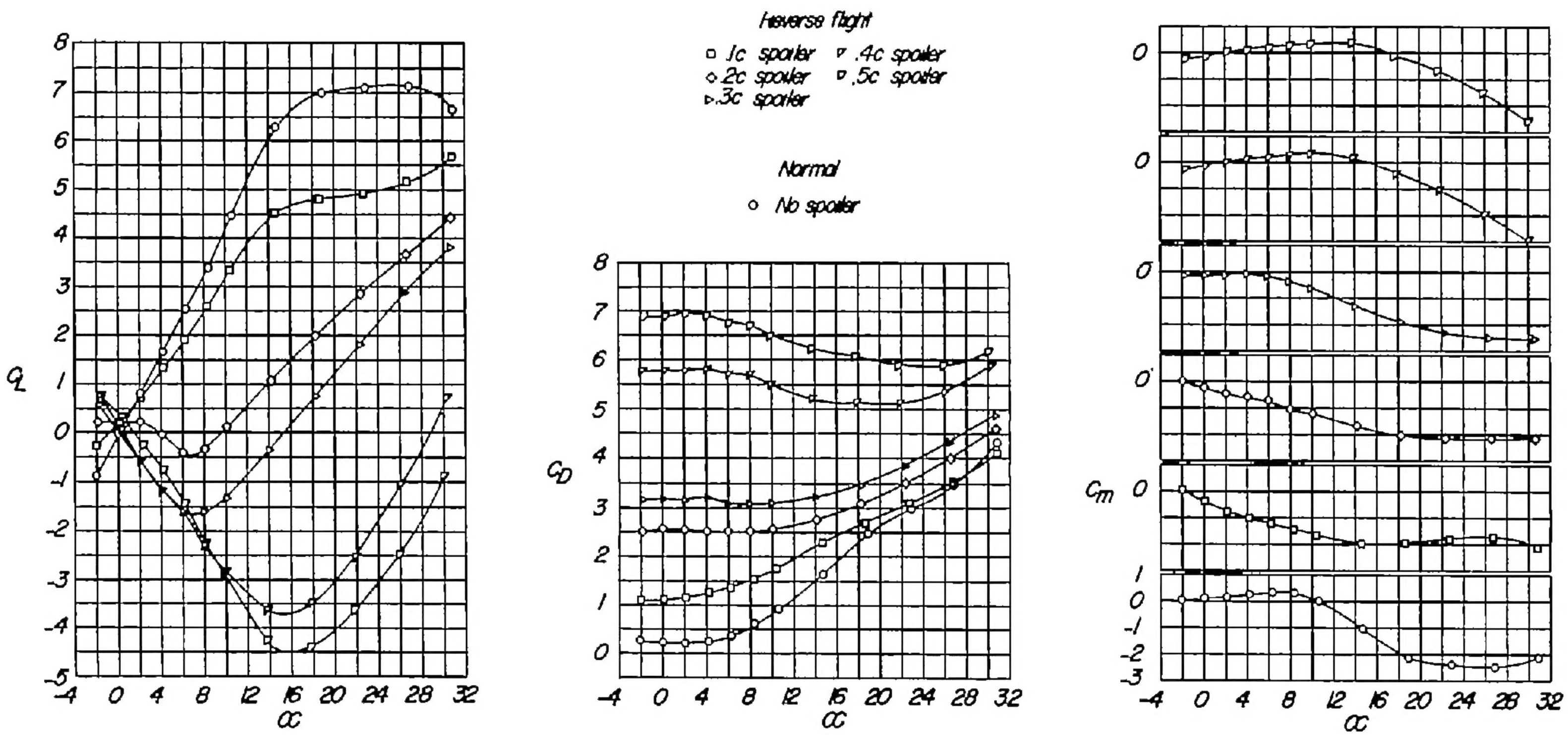

Figure 6.- Effect of spoiler height on the variation of C_L, C_D, and C_m with α for isolated wing of aspect ratio 2.

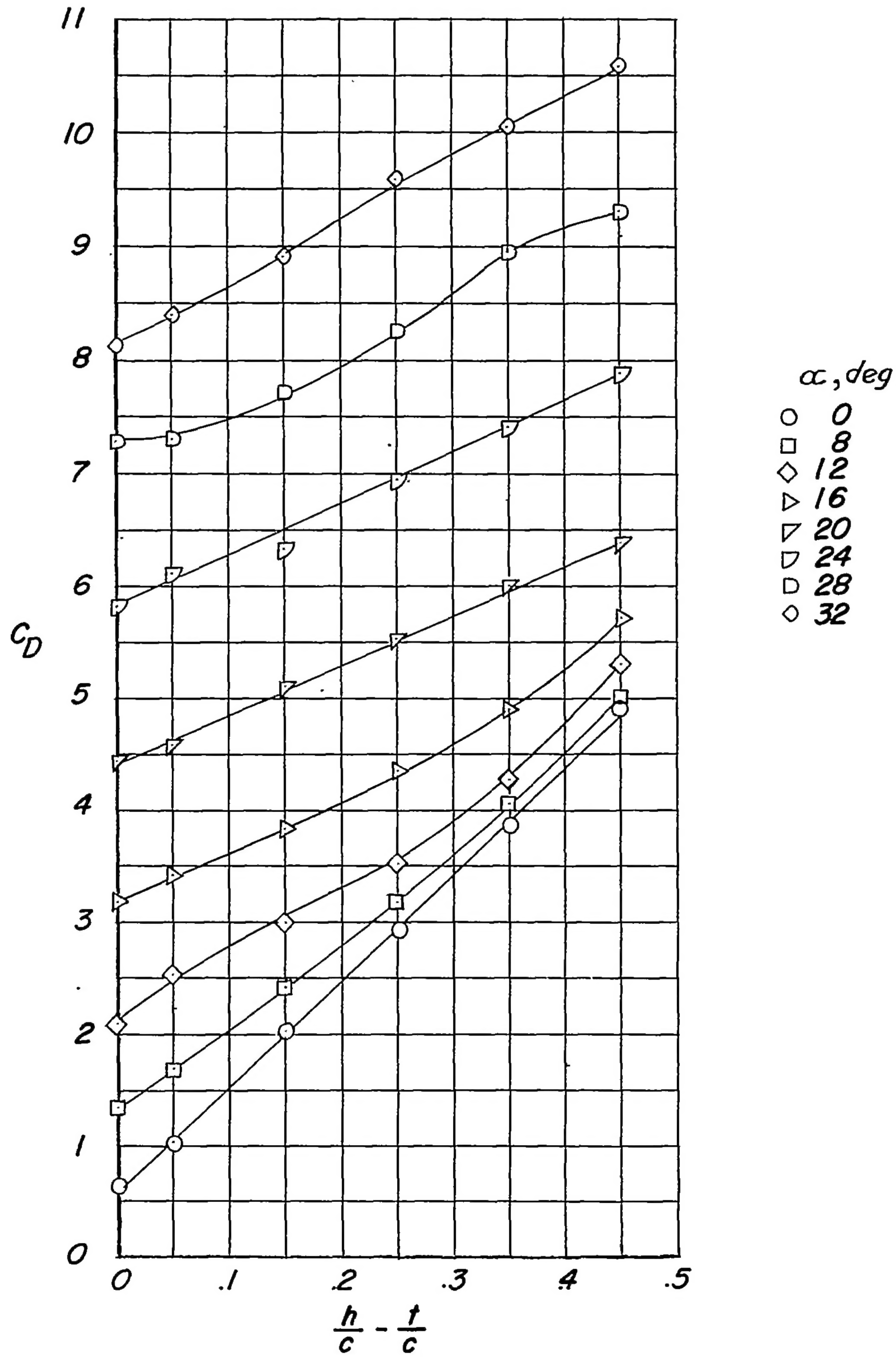

Figure 7.- Variation of C_D with exposed height of spoiler.

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